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Title:	Spatially REsolved Fission Tag (SREFT) - a low-mass TPC
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Spatially REsolved Fission Tag (SREFT) – a low-mass TPC

Leveraging experience from the NIFFTE TPC to tackle other fission observables

Kyle Schmitt

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National Nuclear Security Administration
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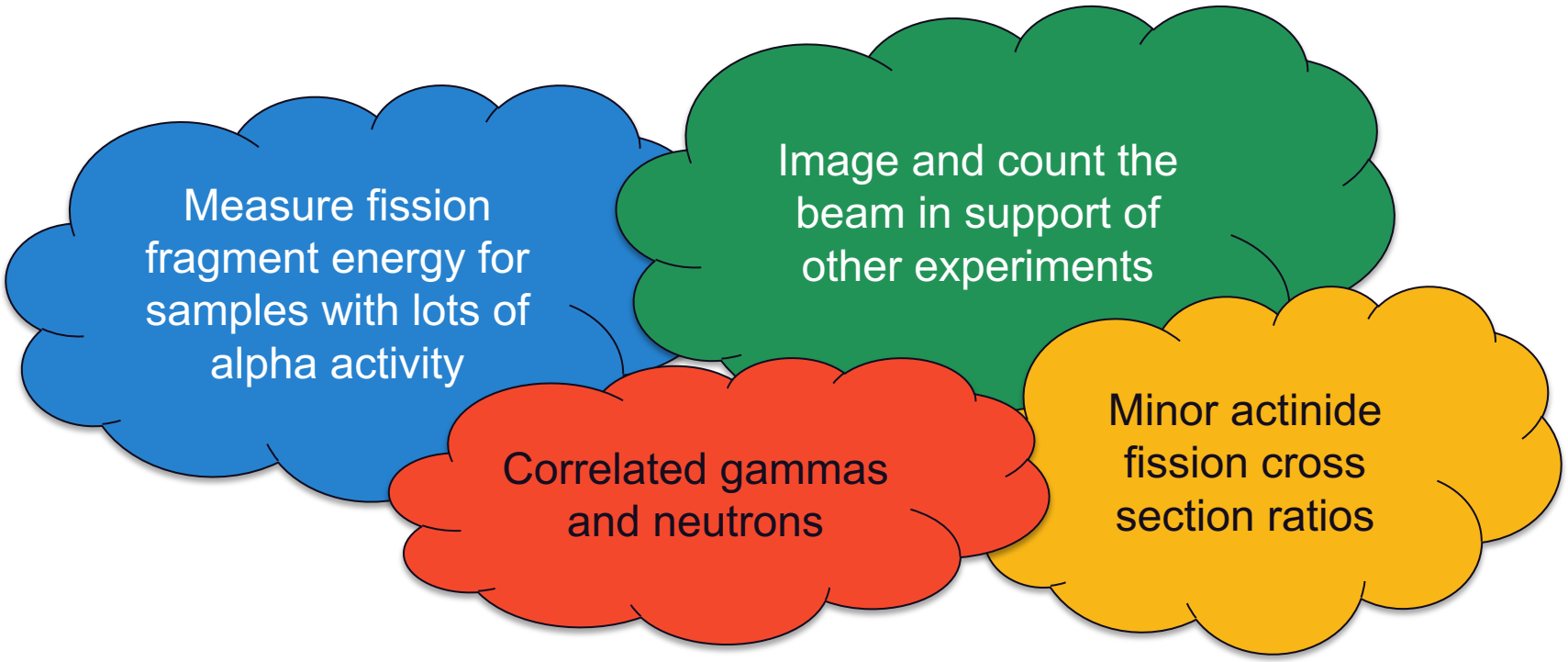
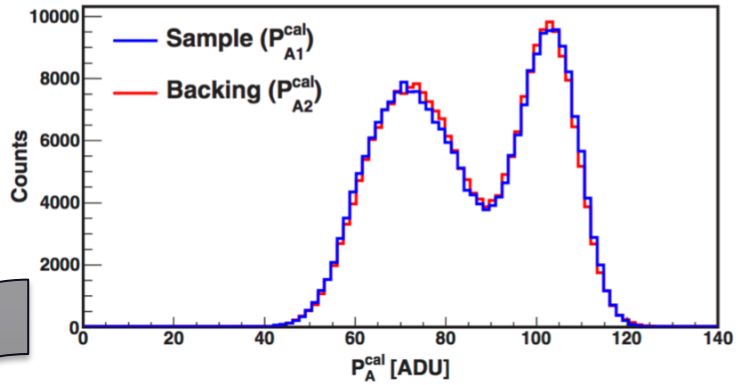

Measure fission fragment energy for samples with lots of alpha activity
Image and count the beam in support of other experiments
Correlated gammas and neutrons
Minor actinide fission cross section ratios

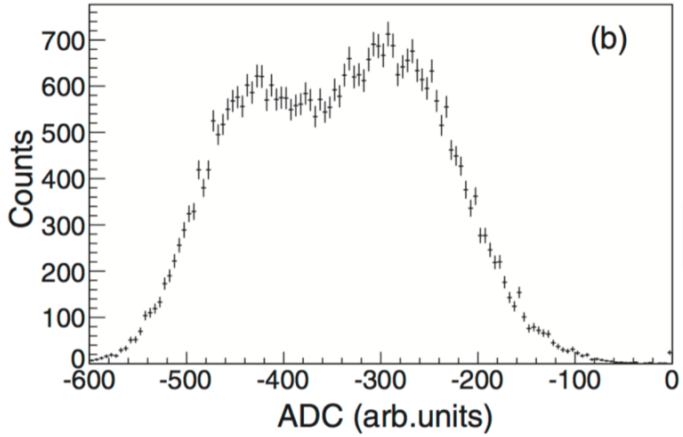
Challenge of high alpha decay rates

^{238}U ($T_{1/2}$ ~10^9 y)



PHYSICAL REVIEW C **94**, 054604 (2016)

^{239}Pu ($T_{1/2}$ ~24000 y)

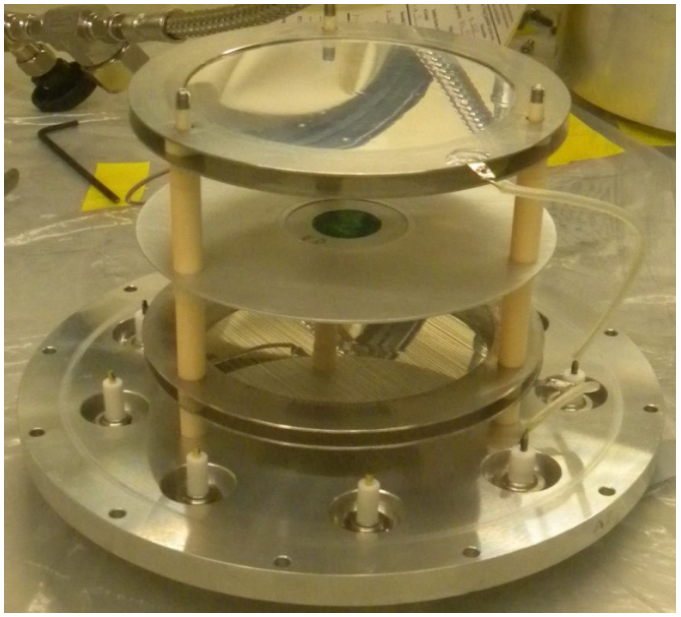


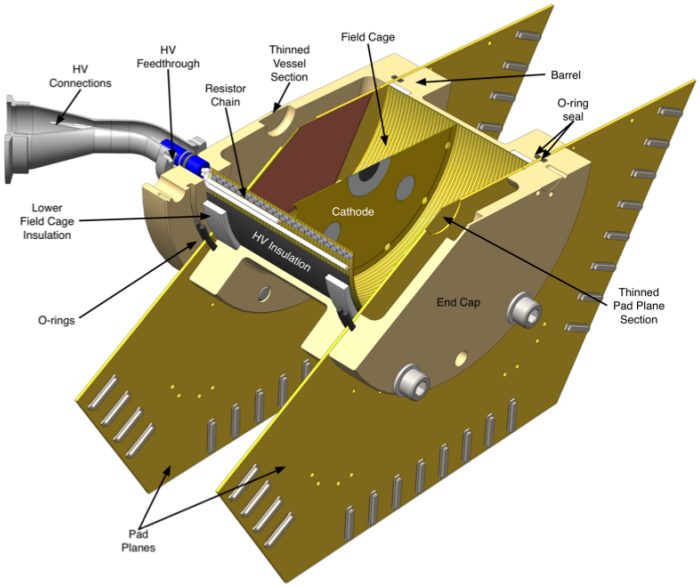
PHYSICAL REVIEW C **94**, 034611 (2016)

^{240}Pu
($T_{1/2}$ ~6500 y)

?

Goal: Measure fission fragment energy for samples with lots of alpha activity





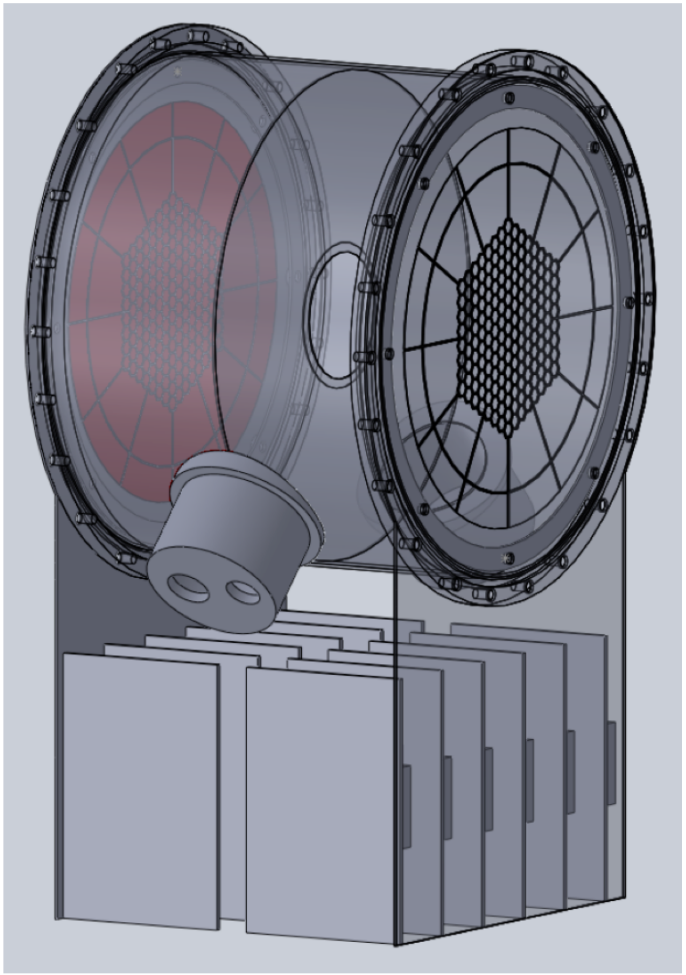
Imagine a world where protons don't matter…

	Hydrogen standard measurement (fissionTPC)	Just measure fission fragments and reject alpha (something new)
Position resolution	0.3 mm	1 mm
Gas pressures	1-10 atm	1 atm
Anode size	11 cm diameter	12 cm diameter
Channel count	6000	400
Dynamic range per pad	~10 keV – 100 MeV	~500 keV – 100 MeV
Gas gain	~50	1
Gas mixtures	Not sure yet	P10

SREFT Design goals

Basic requirement: Reject alphas and count fission fragments

- Anode dynamic range from ~500 keV to ~100 MeV
- Minimal scatter or attenuation for outgoing neutrons and gammas
- ~100% alpha-particle rejection
- Low operational cost (people)
- Energy resolution ~ 1 MeV for fission fragments
- Use drift gas with measured pulse height defect (P10)
- Angular resolution ~3°, vertex resolution ~1 mm



Using our imagination…

Frisch grids

- **Nickel mesh bonded to stainless steel ring by Precision Eforming**
- **100 Lines per inch – more coarse than TPC**
- **Prototypes in hand – tight and smooth**

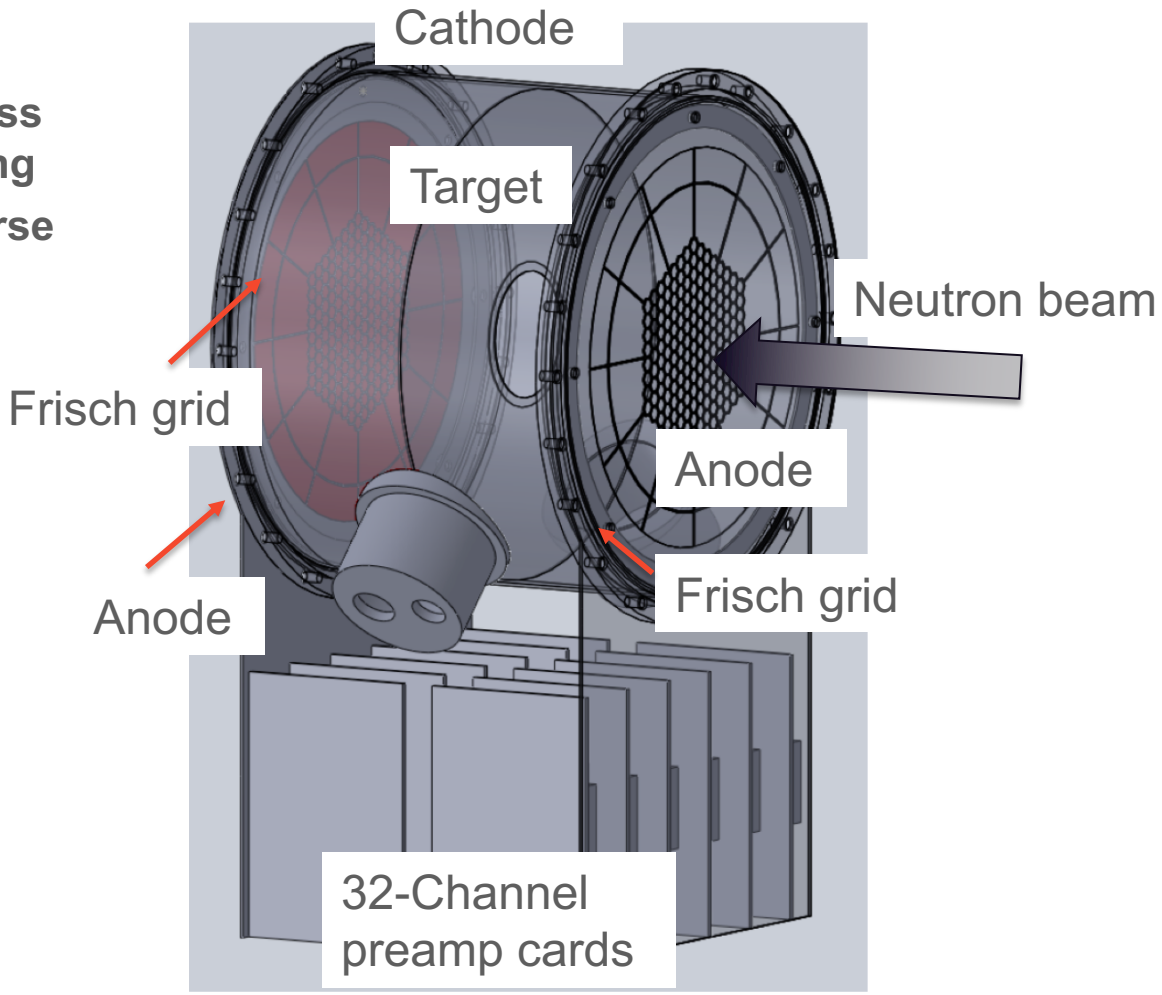
Cathode/field cage

- **Similar design to fissionTPC**
- **PCB design in preparation**

Machined parts

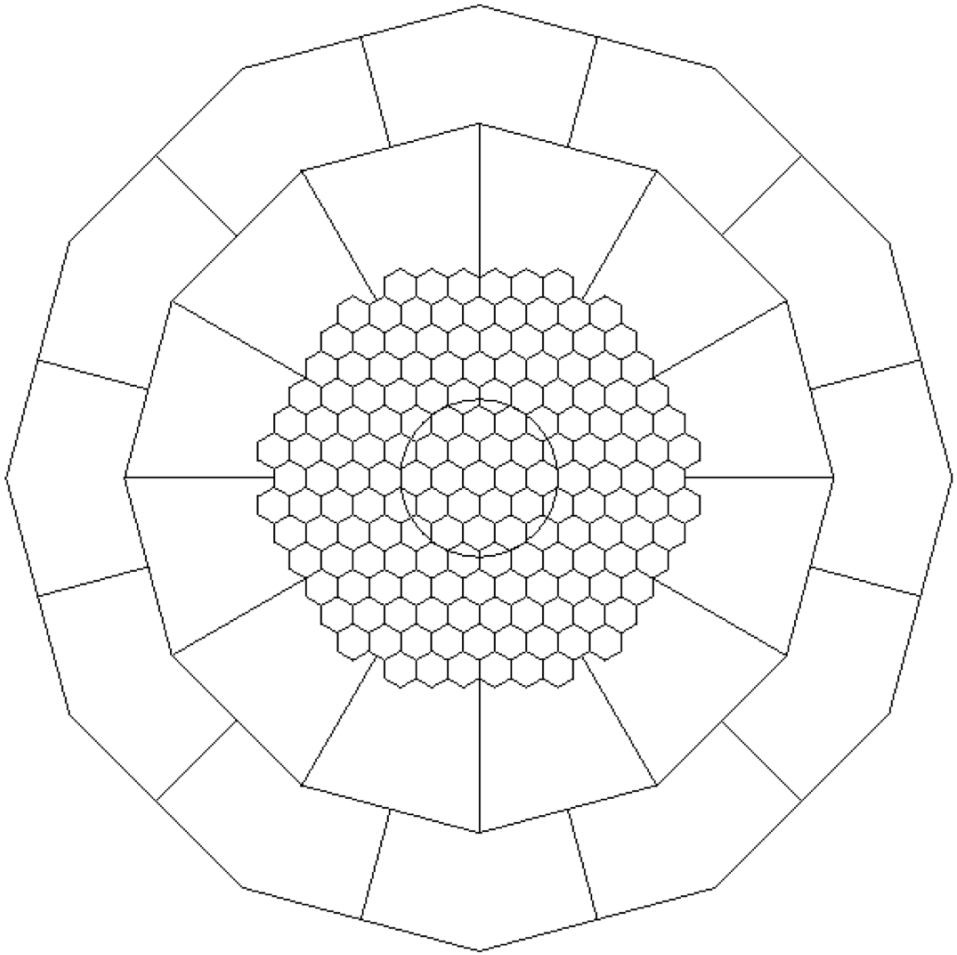
- **Drawings in preparation**

- **CAEN 1740 Digitizers**
  - –64 channels per module
  - –12 bit/ 62.5 MHz(one arriving soon)



Anodes

- 187 Pads per anode
- Fine segmentation in central region (4mm pads)
- Large outer pads overlap azimuthally
- Frisch grid bias passes through board
- PCB acts as part of gas containment vessel
- First prototype to arrive next week



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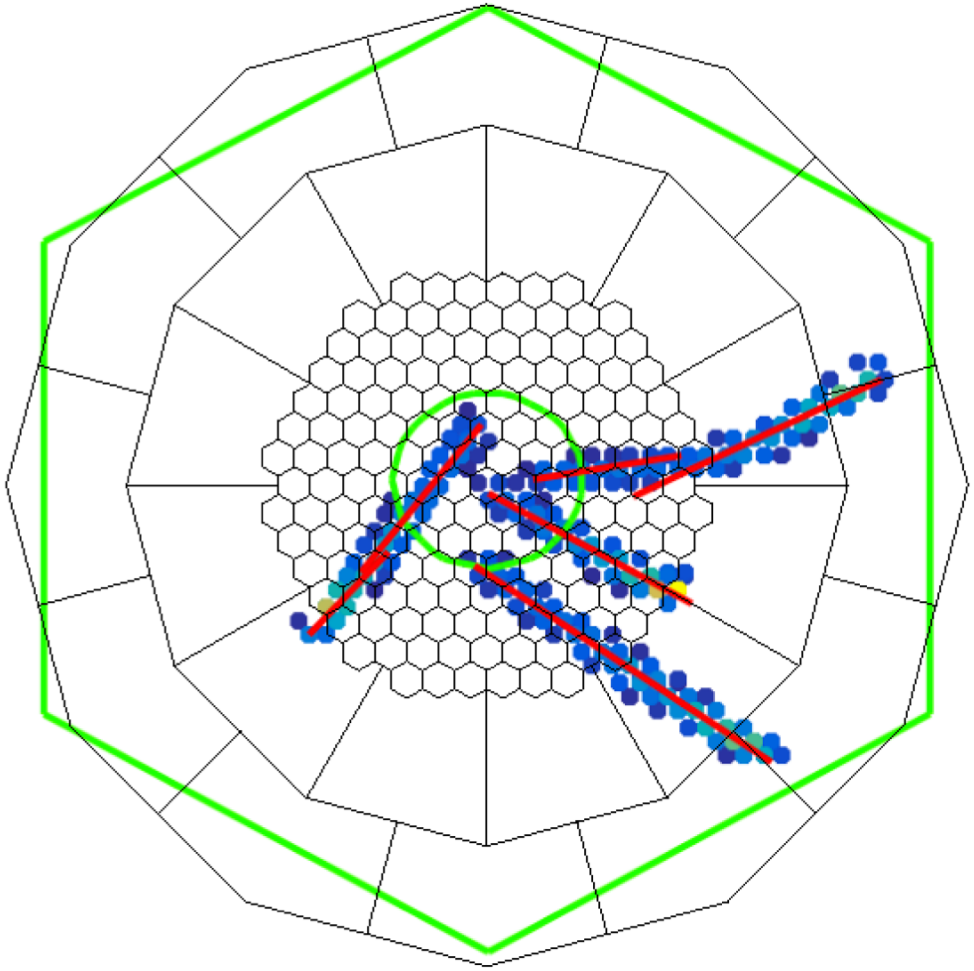
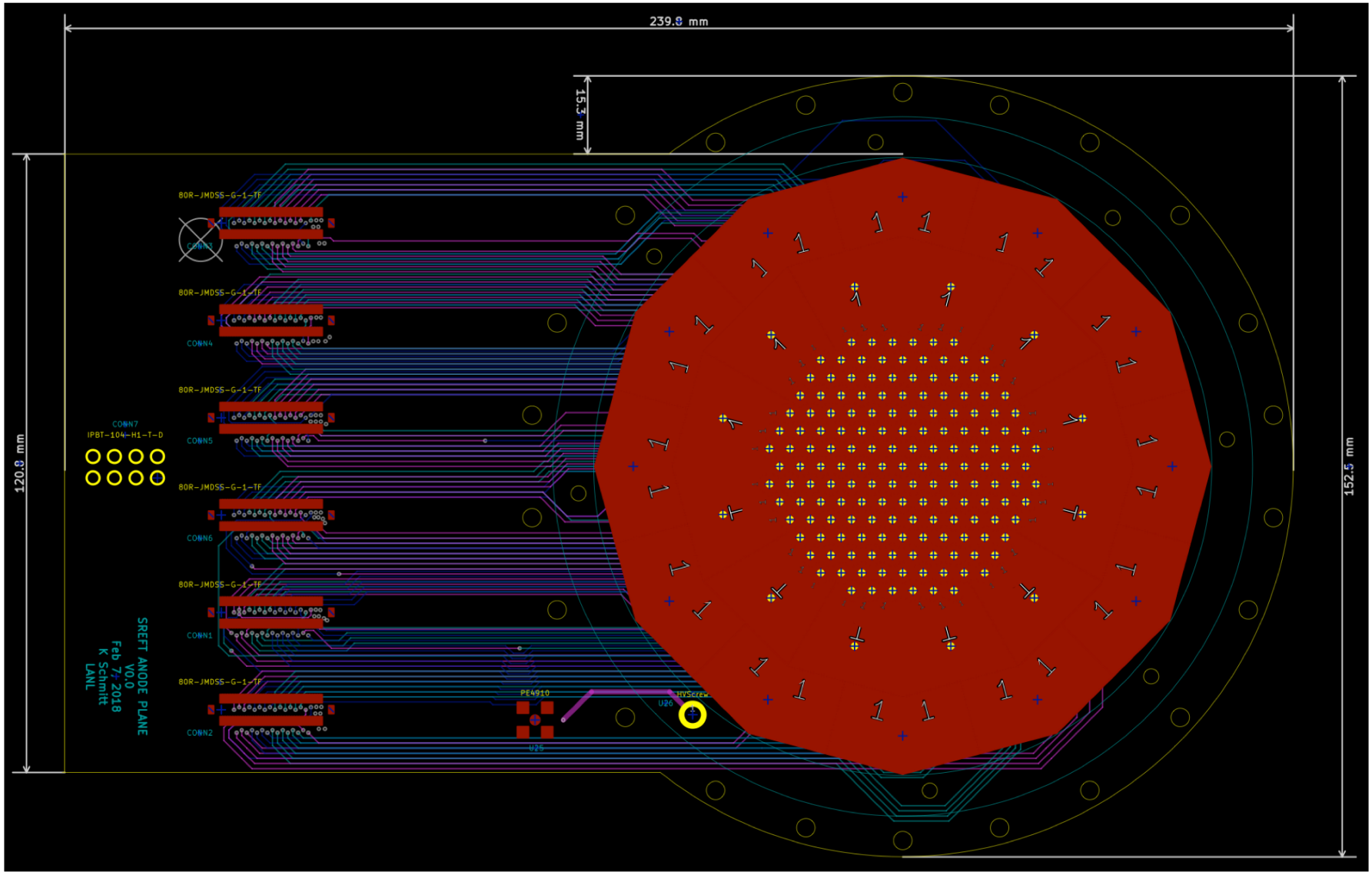
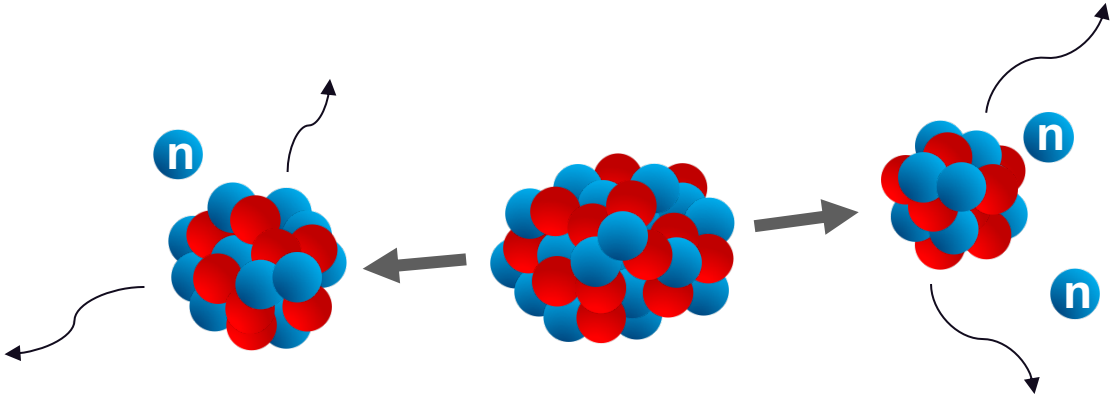


Anode boards



Potential data needs



- Total Kinetic Energy (TKE) of fission fragments with in-situ calibration
- TKE for hot samples (Pu-239, 240, 238?)
- Correlated neutrons and gamma-rays
- (n,α)
- (n,xα)
- Beam imaging in support of other experiments
- Minor actinide fission cross section ratios

We envision an extensive long-term program

- Calibrated TKE measurements and TKE for hot samples
- Correlated neutrons and gamma-rays
- Minor actinide fission cross section ratios
- Beam imaging and flux monitoring
- ^{239}Pu fission cross section in ratio to ^{1}H(n,n) with an ancillary proton-scattering-based detector

How does this relate to the future of NIFFTE?

- Overlapping interests
  - Correlated particles
  - Minor actinide fission cross sections
  - Fission Product Yields (FPY)
- Similar designs
- Some of the same people (Shea, Kyle, Morgan)
- Shared funding?
- Shared hardware?

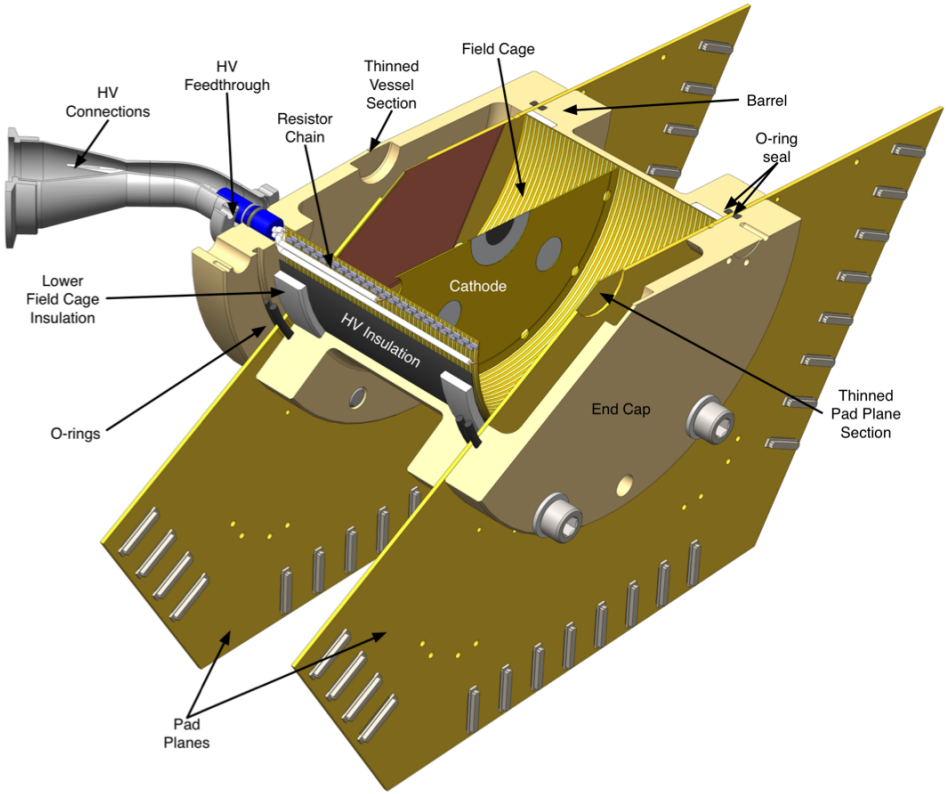
Extra Slides

Goal	Design parameters
Anode dynamic range from ~500 keV to ~100 MeV	No gas gain
Minimal scatter or attenuation for outgoing neutrons and gammas	Thin gas containment vessel and pressure=atmospheric
~100% alpha-particle rejection, angular resolution ~3°, vertex resolution ~1 mm	4 mm segmentation for inner area and ~2 mm Frisch grid gap to disperse signal between tracks, fine segmentation area large enough to catch tracks on ~10 pads
Energy resolution ~1 MeV for fission fragments	Use Michael Mendenhall's resolution minimization method. Low channel count helps.
Use drift gas with measured pulse height defect	P-10 gas (simple gas handling system)
Short development time	Off-the-shelf electronics (CAEN 1740, $150/channel), use NIFFTE preamps

The challenge of starting from scratch (NIFFTE in ~2010)

Basic requirement: Count protons, alphas, and fission fragments

- Anode dynamic range from ~10 keV to ~100 MeV
- Micromegas gas gain ~50?
- Pressure vessel must hold several atm
- Gas handling system must handle exotic gas mixtures
- ~6000 Anode pads, substantial power and cooling requirements
- Nobody has ever done this before
- Waveform digitization is relatively new technology



Important design goals

- **100% α-particle rejection**
- **Good energy resolution for fission fragments**
- **Target imaging makes it possible to mount a Cf-252 target close to the sample for in-situ energy calibration**
- **Thin-walled chamber to allow good ancillary detector efficiency for outgoing neutrons and gamma-rays**
- **Stable operation without constant monitoring**
  - –Low channel count
  - –No cooling required
  - –Modest power budget
  - –Off-the-shelf data acquisition modules inside a cooled rack